# Appliance Test Report SCGAT071126A(1)

## Royal Range, Model RCOS-1
## Full-Size Gas Convection Oven Performance Test
## Revision 1


## Southern California Gas Company
### Customer Programs Department

## Issued Date: December 2007

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# Revision History

| Revision No. | Date | Description | Author |
|---|---|---|---|
| 0 | December 4, 2007 | Initial Release | Ricardo Vargas |
| 1 | September 30, 2009 | Report format change & electrical consumption recalculation. | Ricardo Vargas |
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# Executive Summary

The "Royal Range of California, Inc" Model RCOS-1 full-size gas-fired convection oven (Figure 1) was evaluated for energy performance at the Southern California Gas Company's Commercial Food Service Equipment Testing Laboratory. Southern California Gas Company (SCG) tested the full-size combination gas oven according to the specifications of The American Society for Testing and Materials' (ASTM) standard test method F 1496-99 (2005). To be considered energy efficient, a convection oven must achieve at least ***40% efficiency*** for the heavy-load cooking-energy efficiency test. The "Royal Range" RCOS-1 oven ***passed*** the standards as set forth. The test results for the "Royal Range" RCOS-1 are as follows:

Figure 1
"Royal Range"

***Table ES-1. Summary of ASTM Convection Oven Performance Results***

| | |
|---|---|
| **Heavy-load cooking-energy efficiency (%)** | **45.2** |
| Rated Energy Input Rate (Btu/h) | 70,000 |
| Measured Energy Input Rate (Btu/h) | 71,977 |
| Preheat Time to 340°F (min) | 9.7 |
| Preheat Energy to 340°F (Btu) | 11,910 |
| Idle Energy Rate (*natural gas fuel*) at 350°F (Btu/h) | 12,540 |
| Idle Energy Rate (*combined gas & electrical*) at 350°F (Btu/h) | 14,142 |
| Pilot Energy Rate (Btu/h) | N/A |
| Production Rate (lb/h) | 89.0 |

The heavy-load cooking-energy efficiency test consists of baking thirty russet potatoes on five full-size sheet pans. As specified by the ASTM test method, cooking-energy efficiency is a measure of how much of the energy that an appliance consumes is actually delivered to the food product during the cooking process. Cooking-energy efficiency is therefore defined by the following relationship:

$$\text{Cooking Energy Efficiency} = \frac{\text{Energy to Food}}{\text{Energy to Appliance}}$$

# Mission Statement - Commercial Foodservice Equipment Testing Program

Recent advances in equipment design have produced commercial foodservice equipment that operates more efficiently, quickly, safely and conveniently. Energy efficient commercial equipment reduces energy consumption primarily through advanced technology and design.

The purpose of Southern California Gas Company's Energy Efficiency Commercial Foodservice Equipment Testing Program is to provide energy efficiency measurement data for cost effectiveness modeling in order to establish energy efficiency standards and ratings for commercial food service equipment. This measurement data is then utilized and integrated with typical equipment usage profiles for California Utility Customers participating in the Food Service Equipment Rebate Program.

Equipment performance is determined by applying the American Society for Testing and Materials (ASTM) standard test method for performance. The ASTM standard test method is considered the industry standard for quantifying the efficiency and performance for cooking equipment.

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# Scope

The scope of this test is to evaluate the performance of the "Royal Range" RCOS-1 gas-fired convection oven by using ASTM F 1496-99 (2005) "*Standard Test Method for Performance of Convection Ovens*", for the test procedure and evaluation criteria.

In order to evaluate the oven's energy consumption and cooking performance the following were performed:

- Verify energy rating
- Verify thermostat calibration
- Determine energy input rate, preheat energy consumption and time
- Determine pilot energy consumption
- Verify cooking uniformity [1]
- Verify cake browning [1]
- Determine cooking rate uncertainty
- Determine production rate uncertainty
- Report findings

# Appliance and test overview

The "Royal Range" RCOS-1 is a single deck, natural gas-fired, full size oven equipped with dual burners rated at 35,000 Btu/h each. The inner cavity measured 29.5 inches in height, 24.0 inches in width and 26.0 inches in depth for a total cavity volume of 18,408 cubic inches. The oven came equipped with analog oven controls for an oven cavity light and a mechanical timer. The oven can accommodate up to twelve horizontal wire cooking racks.

The test consisted of taking fresh whole U.S. Number 1 Russet potatoes with an initial temperature of 75 ± 5°F and cooking them until their internal temperature reached 205°F. During cooking, the internal temperature of randomly selected potatoes was monitored using

[1] Was not performed

thermocouples that were inserted at their core until the temperature averaged 205°F on all the instrumented potatoes. Weight measurements were taken before and after cooking to determine cooking energy efficiency and production rate.

The gas volume, pressure and temperature were monitored and recorded as well as the ambient air temperature and pressure. Type J thermocouples were used to monitor the ambient, oven cavity and inner potato temperature. Electrical power measurements were also monitored and recorded. A Logic Beach data logger was used to monitor and record all data. See section "Testing Equipment Inventory" for more detail regarding the testing equipment.

## Comments, Deviations and Exceptions

*Comments:*

The oven is equipped with two (2) burners each rated at 35,000 Btu.

Pilot energy consumption was not measured since the oven is equipped with an electronic pilot-less ignition system

The heating values for each test were obtained from the Gas Company MCS Gas Analysis daily reports.

*Deviations:*

Testing procedures and results are limited to the heavy-load cooking scenario.

Tests for cooking uniformity and browning uniformity were not performed

*Exceptions:*

# Testing equipment inventory

Energy efficiency testing is conducted at SCG's Commercial Food Service Equipment Food Testing Laboratory located at the Energy Resource Center (ERC) in Downey California. The laboratory can provide utility services such as natural gas, water, electricity, sewer and fume exhaust for a variety of tests.

The testing equipment is mounted onto a mobile test bench providing the flexibility of movement within the test lab or for in the field use. The mobile test bench holds a data logger, various pressure and energy transducers. The data logger provides up to 24 channels with 13 bit analog to digital conversion, and sampling rates in excess of 150 samples per second. The bench mounted pressure transducers monitor barometric ambient pressure and natural gas pressure before and after the gas meter. The electrical transducers are capable of measuring different voltage and phase setups. A magmeter allows measurement of water flow. An analog gas meter fitted with an electronic counter is used to measure gas consumption. See Tables TEI 1-1 and 1-2 for inventory and specifications on testing equipment.

***Table TEI 1-1. Testing Equipment Inventory***

| Description | Manufacturer | Model | Quantity |
|---|---|---|---|
| Data Logger | Logic Beach | HLP-10 | 1 |
| Barometric Pressure Transducer | Omega | EWS-BP-A | 1 |
| Differential Pressure Transducer | Dwyer | 607-9 | 1 |
| Thermocouple | Omega | Type J | 14 |
| Gas Meter | American Meter | DTM 200A | 1 |
| Energy Transducer | Hawkeye | 8036 | 1 |
| Magmeter | Omega | FMG-3000 | 1 |

***Table TEI 1-2. Testing Equipment Specifications***

| Description | Measures | Signal output | Measurement range |
|---|---|---|---|
| Data Logger | Data input | Data | Varies |
| Barometric Pressure Transducer | Pressure | 4 - 20mA | 10.20 – 15.72 psia |
| Differential Pressure Transducer | Pressure | 4 - 20mA | 0 – 25 in.-$H_2O$ |
| Thermocouple | Degree Fahrenheit | ± 2 Volts | 32 – 1382°F |
| Gas Meter | Cubic feet | On / Off pulse | 0 or 1 V |
| Energy Transducer | Current, Voltage | Modbus | 2400 A (max)<br>120 – 480 VAC |
| Magmeter | Water flow | 4 - 20mA | 0 – 21 gpm |

The mobile testing bench is equipped with additional testing equipment. The additional testing equipment is listed as miscellaneous testing equipment in Table TEI 2-1.

## Testing Equipment Inventory *(continued)*

***Table TEI 2-1 Miscellaneous Testing Equipment***

| Description | Manufacturer | Model | Function |
|---|---|---|---|
| Power supply | Omega | U24y101 | Converts 120VAC to 24VDC at 1 Amp max. |
| Power supply | Idec | PS5R | Converts 120VAC to 24VDC at 0.3 Amp max. |
| Digital multimeter | Fluke | 189 | Measures Voltage, resistance, current & temperature |
| Digital manometer | Testo | 512 | Measures gauge pressure (0 – 29 psig, 0.5% of fsv.) |
| Pressure gauge | Ashcroft | - | Measures gauge pressure (0 – 15 in.-$H_2O$) |
| Bench scale | A&D | FG-60KAL | Weight measurement (150 lbs. x 0.01 lbs.) |

## Testing Equipment Inventory – Photos

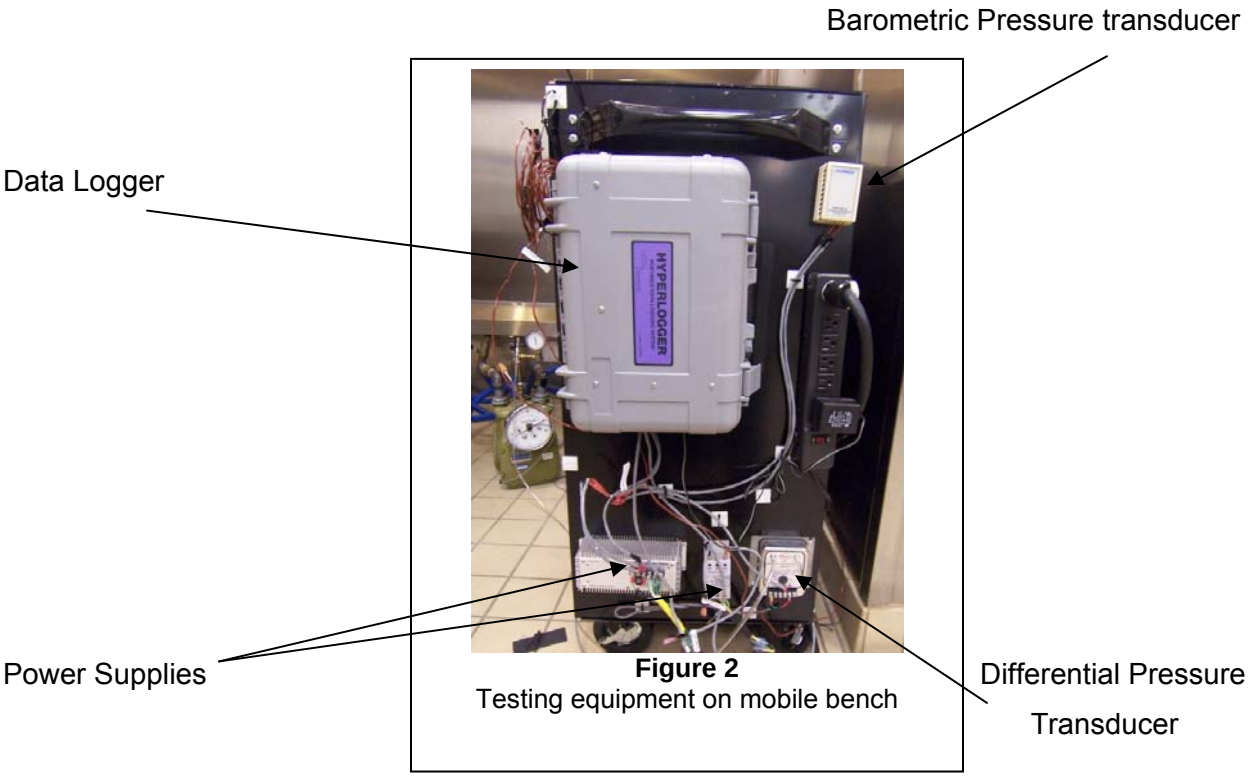


**Figure 2**
Testing equipment on mobile bench

## Testing Equipment Inventory – Photos *(continued)*

Energy transducer

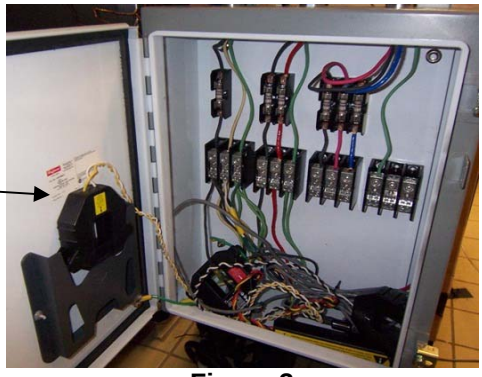

**Figure 3**
Fuse box and energy transducers

Pressure gauge

**Figure 4**
Gas meter and pressure gauge

**Figure 5**
Gas meter & mobile testing bench

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**Performance of Convection Ovens**
**RESULTS SUMMARY (11)**
**ASTM F 1496-99 (2005)**

| | |
|---|---|
| Manufacturer | Royal Range |
| Model | RCOS-1 |
| Date | December 4, 2007 |
| Test Reference Number | SCGAT071126A(1) |

**1. Appliance Type (11.1)** Convection Oven

| | |
|---|---|
| Fuel type: | Natural gas |
| Half-size or Full-size: | Full size |
| Rated input: | 70,000 Btu/h |
| Oven cavity volume (in.$^3$): | 18,408 |

Controls:

At the top of the oven's control panel there is a "Burner On" indicator lamp. Under the lamp there is an analog thermostat control dial with temperature values in increments of 50°F with a maximum setting of 500°F. Below the thermostat there are three (On/Off) control switches for the cavity light, the fan and oven power. Below the switches is an analog cooking timer with a maximum setting of 60 minutes.

Description of operational characteristics:

With the thermostat control dial set at 375°F, the average temperature at the center of the oven was determined to be 349.5°F, within the limit of ± 5°F set forth in the ASTM F 1496-99 test method section 11.2.

**2. Apparatus (11.2)**

√ Check if testing apparatus conformed to specifications in Section 6.

### 3. Thermostat Calibration (11.4)

As-Received:

| | |
|---|---|
| Oven temperature control setting (°F) | 350 |
| Oven cavity temperature (°F) | 328 |
| Oven temperature control setting (°F) | N/A |
| Oven cavity temperature (°F) | N/A |

As-Adjusted:

| | |
|---|---|
| Oven temperature control setting (°F) | 375 |
| Oven cavity temperature (°F) | 350 |
| Oven temperature control setting (°F) | N/A |
| Oven cavity temperature (°F) | N/A |

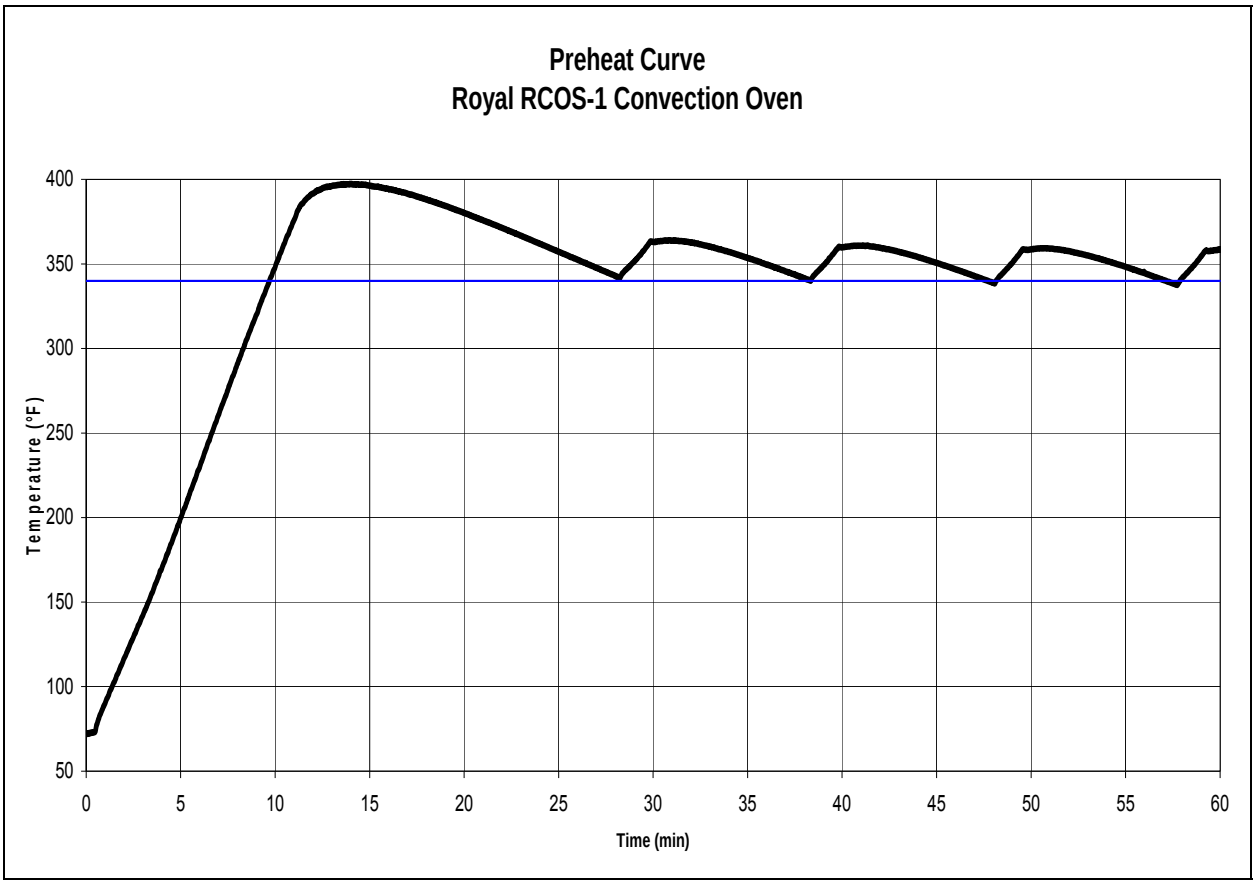
### 4. Energy Input Rate (11.5)

| | |
|---|---|
| Test voltage (V) | 117.2 |
| Higher heating value of natural gas (Btu/ft$^3$) | 1,019 |
| Measured (Btu/h) | 71,977 |
| Rated (Btu/h) | 70,000 |
| Percent difference between measured and rated (%) | 2.8 |
| Gas oven-fan and control energy rate (kW) | 0.55 |

### 5. Preheat Energy and Time (11.6)

| | |
|---|---|
| Test Voltage (V) | 117.1 |
| Higher heating value of natural gas (Btu/ft$^3$) | 1,019 |
| Starting temperature of oven cavity (°F) | 72 |
| Energy consumption of natural Gas (Btu) | 11,910 |
| Electric energy consumption (kWh) | 0.091 |
| Duration (min) | 9.7 |
| Preheat rate (°F/min) | 28 |

## 5. Preheat Curve (11.6)




## 6. Pilot Energy Rate (11.7)

| | *See Comments, Deviations and Exceptions* |
|---|---|
| Gas heating value (Btu/ft$^3$) | N/A |
| Pilot energy rate (Btu/h) | N/A |

## 7. Idle Energy Rate (11.8)

| | |
|---|---|
| Test Voltage (V) | 117.9 |
| Higher heating value of natural gas (Btu/ft$^3$) | 1,018 |
| Idle energy rate at 350°F – *natural gas only* (Btu/h) | 12,540 |
| Idle energy rate at 350°F – *gas & electric* (Btu/h) | 14,142 |
| Electric energy rate at 350°F (kW) | 0.47 |

## 8. Cooking Energy Efficiency, Cooking Energy Rate, and Production Rate (11.9) [2]

*Heavy-Load:*

| | |
|---|---|
| Test voltage (V) | 116.7 |
| Higher heating value of natural gas (Btu/ft$^3$) | 1030 |
| Cooking time (min) | 49.0 |
| Production rate (lb/h) | 89.0 |
| Energy to food (Btu) | 17,943 |
| Cooking energy rate (Btu/h) | 48,718 |
| Electric energy rate (kW) | 0.45 |
| Energy per pound of food cooked (Btu/lb) | 548 |
| Cooking energy efficiency (%) | 45.2 |

*Medium-Load*: *See Comments, Deviations and Exceptions*

| | |
|---|---|
| Test voltage (V) | |
| Higher heating value of natural gas (Btu/ft$^3$) | |
| Cooking time (min) | |
| Production rate (lb/h) | |
| Energy to food (Btu/lb) | |
| Cooking energy rate (Btu/h) | |
| Electric energy rate (kW) | |
| Energy per pound of food cooked (Btu/lb) | |
| Cooking energy efficiency (%) | |

*Light-Load:* *See Comments, Deviations and Exceptions*

| | |
|---|---|
| Test voltage (V) | |
| Higher heating value of natural gas (Btu/ft$^3$) | |
| Cooking time (min) | |
| Production rate (lb/h) | |
| Energy to food (Btu/lb) | |
| Cooking energy rate (Btu/h) | |
| Electric energy rate (kW) | |
| Energy per pound of food cooked (Btu/lb) | |
| Cooking energy efficiency (%) | |

[2] Test results based on the average of three (3) iterations.

**9. Cooking Uniformity (Frozen Macaroni & Cheese) (11.10)**

*See Comments Deviations and Exceptions*

| | |
|---|---|
| Test voltage (V) | |
| Higher heating value of natural gas (Btu/ft$^3$) | |

| Rack | Average Rack Temperature (°F) |
|---|---|
| 1 (Top) | |
| 2 | |
| 3 | |
| 4 | |
| 5 (Bottom) | |

| | |
|---|---|
| Cooking time (min) | |
| Production capacity (lb/h) | |
| Energy to food (Btu/lb) | |
| Cooking energy rate (Btu/h) | |
| Electric energy rate (kW) | |
| Cooking energy efficiency (%) | |

**10. Browning Uniformity (White Sheet Cakes) (11.11)**

*See Comments Deviations and Exceptions*

| | |
|---|---|
| Test voltage (V) | |
| Higher heating value of natural gas (Btu/ft$^3$) | |
| Initial cake temperature (°F) | |
| Final cake temperature (°F) | |
| Initial cake weight (lb) | |
| Final cake weight (lb) | |
| Sheet cake cook time (min) | |
| Sheet cake cooking energy (Btu) | |
| Electric energy (kWh) | |

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**Performance of Convection Gas Ovens**
**UNCERTAINTY RESULTS FOR COOKING ENERGY EFFICIENCY**
**Annex A1.**

| | |
|---|---|
| Make: | Royal Range |
| Model: | RCOS-1 |
| Equipment Type: | Full-size gas convection oven |
| Calculations from: | ASTM F 1496-99 (2005) Annex A1 |
| Results Evaluated: | Cooking Energy Efficiency (%) |

A. Iteration results

| | | |
|---|---|---|
| 1. Iteration 1 | $X_1$ = | 43.8 |
| 2. Iteration 2 | $X_2$ = | 45.7 |
| 3. Iteration 3 | $X_3$ = | 46.0 |
| 4. Iteration 4 | $X_4$ = | |
| 5. Iteration 5 | $X_5$ = | |

B. Uncertainty results

| | |
|---|---|
| Average **$Xa_n$ =** | 45.2 |
| Standard deviation **$S_n$ =** | 1.19 |
| Absolute Uncertainty **$U_n$ =** | 2.95 |
| % Uncertainty **$\%U_n$ =** | 6.5 |

**Performance of Convection Gas Ovens**
**UNCERTAINTY RESULTS FOR PRODUCTION RATE**
**Annex A1.**

| | |
|---|---|
| Make: | Royal Range |
| Model: | RCOS-1 |
| Equipment Type: | Full-size gas convection oven |
| Calculations from: | ASTM F 1496-99 (2005) Annex A1 |
| Results Evaluated: | Production Rate (lb/h) |

C. Iteration results

| | | |
|---|---|---|
| 1. Iteration 1 | $X_1$ = | 89.1 |
| 2. Iteration 2 | $X_2$ = | 91.4 |
| 3. Iteration 3 | $X_3$ = | 86.5 |
| 4. Iteration 4 | $X_4$ = | |
| 5. Iteration 5 | $X_5$ = | |

D. Uncertainty results

| | |
|---|---|
| Average **$Xa_n$ =** | 89.0 |
| Standard deviation **$S_n$ =** | 2.45 |
| Absolute Uncertainty **$U_n$ =** | 6.08 |
| % Uncertainty **$\%U_n$ =** | 6.8 |

Signatures: The undersigned has performed stated tests and has verified that the results recorded were the actual results observed.

SCG's Tester:

(signature) (date)

Ricardo Vargas

(print name)